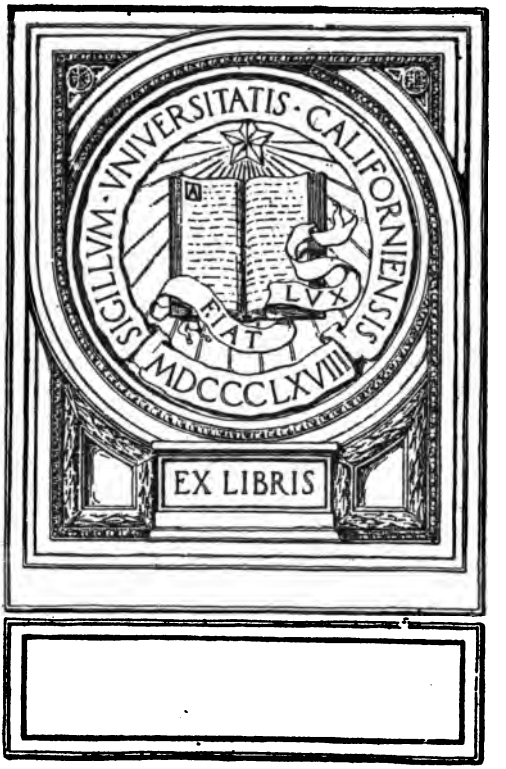
INSTRUCTIONS TO LOCATING ENGINEERS

F. LAVIS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INSTRUCTIONS
TO
LOCATING ENGINEERS
AND
FIELD PARTIES

By
F. LAVIS

Member American Society of Civil Engineers
Member American Railway Engineering Association
Author of "Railroad Location Surveys and Estimates"

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PREFACE.

These instructions were originally prepared by the Author for the use of Field parties working under his direction in the United States, afterwards modified for use in South America, and finally prepared in the present form for use in China. At the suggestion of some who have used them, this last printing was amplified so that copies might be available for the general use of engineers.

They are, as will be seen, intended to secure uniform practice in making surveys and in the compilation of the results in the form of maps, estimates, etc., and are intended to be issued by Chief Engineers to their subordinates in the field.

As conditions vary so much even within the confines of the United States and much more so of course in different foreign countries, modifications, in the form of special instructions will be required to meet local conditions, though the general conditions to be complied with remain the same. Provision is therefore made for the necessary flexibility in this respect.

January, 1917. F. LAVIS.

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GENERAL

The following instructions are issued for the general purpose of insuring uniformity of practice in the conduct of Field Work for the Location of Railroads and also in the preparation of maps, profiles and reports showing the work accomplished.

They have been prepared generally on the basis of usual practice in the United States and will necessarily be modified to meet special conditions and to conform with required practice or special Governmental regulations in Foreign countries in which case special instructions will be issued by the engineer in charge.

The instructions should be read and understood by all members of the party. It is not only necessary that each should know what is required of **him**, but also that each should have some idea at least, of what is required of the others, so that intelligent cooperation, without which there can be no success in the conduct of Location, will be assured.

SUPPLEMENTARY INSTRUCTIONS.

The Engineer-in-charge will see that these instructions are followed and that each member of the party performs his duties in the manner set forth herein. Special instructions may be issued from time to time supplementing these, duplicate copies of which will be furnished, one to be posted for the information of the party and the other attached to the office copy of these instructions.

EQUIPMENT.

On taking charge of a party, Locating Engineers will see that they have a full equipment of instruments, stationery and supplies necessary to carry out the work according to these instructions. General lists are given at the end which will serve as a guide and may be modified to suit the country and the work to be accomplished. Locating Engineers will be furnished such

maps as can be obtained, from headquarters, and should obtain any others which are available and which may be of use.

CARE OF EQUIPMENT.

All equipment should be kept in a proper state of efficiency, engineers in charge reporting from time to time on its conditions. Instruments will be kept in adjustment, rods, etc., kept painted, so that figures and colours are bright and distinct, tents kept in repair, etc., etc. Great care will be taken to avoid damage to instruments; as a rule adjustments should only be made by the engineer in charge, or his assistant, or under his supervision. When instruments are carried in any vehicle they should be placed in the box and held by some person.

PURCHASE OF SUPPLIES.

When supplies are not furnished by the company but are bought directly by the Locating Engineer, they should be purchased in the largest quantities which can be properly utilized, and in unbroken packages, that is: by the case, bag, barrel, etc., so as to take advantage of wholesale prices and discounts. It is expected that the men will be well though economically fed.

The railroad company furnishes transportation when necessary and possible, also heat, light, cooking and camp equipments, and boards each member of the party. Each man furnishes his own personal effects, such as drafting instruments, clothing, bedding, etc. Mosquito nets will be furnished by the company if necessary. No form of cot, except the regulation standard folding army cot (or cots of a similar kind, as may be allowed by the engineer in charge) will be permitted in camp.

REQUISITION FOR STATIONERY.

Requisitons for stationery and other supplies furnished by the company will be made on the first of the month only—except in emergencies—and through the office of.....
.....clear and explicit shipping directions must be given with **each** requisition.

CORRESPONDENCE.

Use standard form of letter heads for all correspondence when such forms are available. Where they are not, use standard size letter sheets 8½ x 11. Write on one side only. Give

on **each** letter, post office address, telegraph, telephone and express addresses where any are available. Copy in letter copy book (Bushnell's) which will be furnished, or keep carbon copy. Address all correspondence to.....

TELEGRAMS.

When necessary, leave instructions with nearest telegraph office and convenient livery stable to forward telegrams promptly.

DIARY.

Engineers in charge will keep a diary which will be written up **every night,** recording state of weather, work done during the day, country passed through, resources, construction materials available, etc. This diary is to be kept in a regular note book and turned in at the end of the survey. From this diary a report will be made up and sent to the Chief Engineer at the end of each week covering the work done during the week. With this report is to be sent a tracing of that portion of the 5000 ft. map showing all lines run during the week and any additional information or corrections to the topography, etc., developed by the surveys. There should be a statement showing the number of miles of line run; exploratory, preliminary and final, and miles of topography taken.

All members of parties will carefully guard all plans, profiles, etc., and all information developed by the survey. Divulging information of this character will be regarded as evidence of incompetency or dishonesty.

ACCOUNTS.

FUNDS.

Special instructions may be issued in regard to arrangements for furnishing the Locating Engineer with funds for expenses. In default of such special instructions the following method will be adopted. The engineer in charge will make requisition on the Chief Engineer for such amounts as he may need. A running account will be opened with him at the head office, debiting him with the amounts advanced and crediting him with the amount of expenditure as shown by his expense account.

EXPENSE ACCOUNTS.

The expense account will be made up as soon as possible after the first of each month and forwarded to the Chief Engineer, together with all vouchers, receipts, etc. Receipts will be obtained for all amounts expended over one dollar, including railroad fares, and should be in duplicate, one copy being retained by the engineer in the field. Bills should be made out in his name so that they may be easily identified. The expense account will be accompanied by a statement or balance sheet showing moneys received to date, amounts of expense accounts rendered and the credit or debit balance to date in the form shown below. If any discrepancies appear when comparison is made with the account at headquarters, the engineer in charge wil be notified, but if correct, no acknowledgement will be made.

STATEMENT.

The X. Y. & Z. Railroad
in account with
John Jones, Locating Engineer.
Aug. 31, 1911.

	To balance cash on hand July 31, 1911.....		$345.91
Aug. 10	To cash received cheque No. 785943.....		200.00
Aug. 15	To cash received cheque No. 787243.....		200.00
	Total cash		$745.91
	To expenses as follows:		
Aug. 3	Feed for horse as per bill G. Rundle..	$ 7.42	
Aug. 7	To supplies as per bill M. Wiley & Sons	23.60	
	To meat (1 hog) as per bill L. Shuman	17.00	
	etc., etc.		
	Total expenses		489.43
	Balance cash on hand		$256.48

PAYROLLS.

Payrolls will be made up and mailed not later than the last day of each month. Time will be calculated on a monthly basis, fractional parts of a month being calculated as a proportion of the number of days in that particular month. Amounts should

be calculated to the nearest { five cents. / cent } When men are discharged or leave the service of the company, regular discharge checks (time checks) on the proper form must be issued in all cases. These may be taken up and paid by the Locating Engineer if he is in funds, and it is desirable that he do this if possible. When paid they will be receipted by the men to whom they are issued.

Discharge checks paid by the engineer in charge will be attached to the payroll and separate cheque will be issued covering them. They must not be included in the expense account. No deductions may be made on the payrolls except for wages paid on discharge checks. The company will not undertake to protect any personal advances.

All men will be returned free to the place at which they were engaged—excepting by agreement to the contrary—unless discharged for disobedience or incompetency, or leaving without the full consent of the engineer in charge. Two weeks' notice of intention to leave the service will be required, unless such requirement be waived by the engineer in charge. The amounts of all payrolls and expense accounts will be distributed as nearly correctly as possible between the items shown on the form given on the following page:

ITEMS.	C	Exploratory		Preliminary		Location		Total
		A	B	A	B	A	B	
1. Cost of Camp Outfit								
2. Cost of subsistence, food								
3. Cost of subsistence, cooking								
4. Cost of teams & transportation								
5. Running and platting lines and levels...								
6. Number of miles								
7. Cost per mile								
8. Taking and Platting topography								
9. Number of miles								
10. Cost per mile								
11. Drainage areas, land lines, etc.								
12. Office work projecting location, profiles of projected locations, estimates, etc..								
13. Chargeable to other work.....								
Total.....								

NOTES:

Put Item 1 in column C.

Put Items 6, 7, 9, 10 in columns A under proper heading.

Put Items 2, 3, 4, 5, 8, 11, 12, 13 in columns B under proper heading.

The addition of columns C and B should equal the amount of payroll and expense accounts for the month.

Item 13 should be explained in detail.

THE SURVEY.

GENERAL.

Before starting surveys for any particular line, instructions will be issued indicating the character and purpose of the line, the volume of traffic for which the line is to be designed or number of daily trains, types of locomotives, etc. The locating engineer will be furnished with a copy of standard specifications for construction and the requirements of these specifications must be kept in mind in designing the location.

So far as may be consistent, it is advisable for the engineer in charge to take the members of the party into his confidence as to the objects of the survey and the results to be attained, allow them to get a good idea of the topography of the country by frequent study of the maps, and encourage them in every way to take an intelligent interest in the development of that intimate knowledge of the country which is essential to proper location. It is desired that, so far as is possible, the engineer in charge should assume the attitude that the location is to be made by the party rather than by any one man in it.

EXPLORATORY LINES.

Reconnaissance in the generally accepted sense of that word will not, as a rule, be necessary, as the general route of the lines proposed has been determined and will be indicated to Locating Engineers. It is often necessary and generally desirable to run a rapid preliminary or rather exploratory line over the proposed route to get a general idea of the topography and to make a general preliminary determination of the ruling grade. This should cover the whole route and should preferably be done by a small stadia party working under the direction of the locating engineer. For this line no attempt should be made to study the location in detail but the line should be run where it will encounter fewest difficulties due to topographical or other conditions. Many short side lines and deviations can be examined roughly by stadia or compass lines at far less expense than by the usual methods of running preliminary lines, and the engineer in charge is expected to make intelligent use of all these aids to a proper and full development of the country at the smallest expense possible, while at the same time obtaining full and adequate information.

PRELIMINARY SURVEY.

The Preliminary Survey proper is to serve as a basis for the final location. The object of this survey is to make a topographical map of the strip of country through which the final location will pass and through which runs a sufficiently accurate base line or lines, and on which map the best line the country affords, under the governing conditions, can be projected in such a manner that it can afterwards be reproduced on the ground.

In order to avoid undue expense and loss of time it is desirable that the preliminary lines should be run as closely as is practical to where the final location will lie, but no time should be wasted in an endeavour to make the preliminary lines preliminary location. The projected location is to be made from the topography. The value of the Locating Engineer to this Company will be shown by his comon sense in interpreting these instructions and by his ability to so locate his preliminary lines that they will be of the greatest value as bases:

1st For the acquisiton of the necessary topography.

2nd For laying out the final location.

TOPOGRAPHY.

While it is absolutely essential that all the topography necessary to determine the final location should be obtained, it must be borne in mind that the object of the survey is **not to make a topographical map but to locate a railroad** and topography is only a means to that end. The topography must be sufficiently **accurate** and **ample** for the purpose for which it is required but anything beyond that is wasteful of money and will tend to injure the reputations of those concerned. Topography will be taken usually for 300 ft. on either side of the center line.

In densely wood country, or on steep side hills, run parallel lines to better control the topography.

At important river crossings, develop the topography for at least 1500 ft. and unusually 3000 ft. on either side of the line of the railroad. Survey all railroad lines crossed, for at least one (1) mile on either side of line, locate all tracks, buildings, fences, etc., get levels at base of rail and note height of rail. Locate overhead crossings with other railroad lines whenever possible.

TRANSIT LINES.

Use every effort to carry forward a continuous stationing on the main preliminary line. Give all preliminary lines a letter, omitting I and J and reserving L for the location. Start the stationing of each line at 0. Careful ties are to be obtained to all land lines, plats of towns and villages, street layouts, political boundaries, etc. Observations should be made every 25 miles or so to determine the correct bearing of the line and the magnetic variation, observations made during the progress of the preliminary survey should be referenced so that the final location may be tied in to them.

PRELIMINARY PROFILES & MAPS.

Profiles are to be taken of all preliminary lines and platted, though it is not considered that these profiles will necessarily be representative or typical of what may be obtained by the final location—they are to be used for what they are worth.

All lines and levels are to be platted on the night of the day they are run—plat all lines whether abandoned or not. All platting except topography is to be checked. If the line is platted by the draftsman it should be checked by the transit man or assistant engineer.

All the work should be kept up to date, no part being allowed to drag behind. The projected location, profile, estimates and distributions should be kept up as close as the topography will allow. The distribution of quantities will be made and shown on profiles of projected locations as well as finals. All maps, profiles, estimates and records of all kinds **will be completed,** so far as practicable, **while the surveys are in progress.** There must be no accumulation at the close of the work. This is **very** important. The locating engineer in charge of the party will be held personally responsible for results and he, therefore, should not keep men who cannot do first class work after a thorough trial and after **proper instructions have been given them.**

GRADES.

The ruling grade will be specified by special instructions to be issued as may be required. It is to be understood that the ruling grade will be the maximum. Momentum grades will not be used except by special instructions. If places are found

where it appears to be feasible to introduce momentum grades and thereby cheapen construction, a special report should be made. The same applies also to pusher grades. (See Table at end.) Ruling grades on curves will be compensated as follows:

COMPENSATION FOR CURVES.

All 1° curves 0.05% per degree.

All curves over 1° usually 0.04% per degree.

On long supported lines, where it is necessary to get all the rise possible, and in other places where economy in construction can be shown to warrant it, as follows:

2° curves 0.08%
3° curves .12%
4° curves .15%
5° curves .18%
6° curves .20%
over 6° curves at the rate of 0.033% per degree.

Show on the bottom of the profile, immediately above the curves, the rate of compensation used.

Break grades at even stations only and show elevations on profile. Use grades of even tenths except where compensation makes it **necessary** to use hundredths, in which case eliminate. the hundredths from the elevation of even stations as soon as possible. As the shortest freight train covers several stations, there is no virtue in starting and stopping the compensation exactly at the P. C. or P. T. Almost always the total compensation on any particular curve can be allowed for and still keep the rate of grade at some even tenth. This should be done as far as possible. Additional compensation must be provided for sidings, stations, etc., and special care must be taken to provide for this on long supported lines.

COMPENSATION FOR SIDINGS.

Allowance will usually be made for sidings long enough to accommodate the maximum length of train of empty cars which can be hauled on the grade adopted, by the largest engine it is proposed to use, in regard to which information will be furnished. The grade at sidings and for an equal length below and half the length above, must be at least 20% less than the ruling grade (i. e., not over 0.8% on 1% ruling grade, etc.). The grade on the

upper side of the stations, water tanks or other stopping places, must be similarly reduced for a distance equal to the length of the maximum train.

TUNNELS.

The rate of grade through tunnels, and for at least a train length below the portals, should not exceed three-quarters the rate of the ruling grade. Where the ruling grade is less than 0.8% compensate at least 0.2 ft. per station.

VERTICAL CURVES.

Vertical curves must be used where the change in gradient is 0.2% or over and the length must be so proportioned that this rate of change will not be exceeded between any two stations.

CURVES.

It is desired to limit the curvature to ..... degrees. Sharper curves (up to.....degrees) may be used if necessary but must be avoided at points likely to be dangerous, such as the foot of steep gradients, etc.

Curves must be of even degree.

No curves should be used as a rule with less than 3° of central angle or less than 300 ft. long.

Avoid broken back curves.

Avoid curves on bridges if possible. The end of a curve should in no case come within 300 ft. of a bridge.

Tangents between reversed curves should not be less than 500 ft. in length and between curves in the same direction not less than 1000 ft.

Stakes must be set every 50 ft. on curves of 8° and over.

Tangents should be run to an intersection if reasonably possible and the P. C. and P. T. set by measurement from the P. I. (or the intersection calculated from a traverse).

On curves over 4° allowance should be made for spirals.

The P. C. and P. T. can be set over on the necessary offset and the curve run in as a simple curve on the offset line, if this seems desirable.

No sights on curves should be taken over 800 ft. in length or which require a deflection angle of more than 15°.

ECONOMIC VALUES.

Special instructions will usually be issued in regard to the values to be used for curvature, rise and fall, distance, etc. In

default of these use the values given below, all of which are based on the assumption that "one train" daily is one train in one direction.

CURVATURE.

The diagram Fig. A 1 gives values for different degrees of curvature and different operating conditions; and a short table should be made out for each line to suit the conditions.

Instructions will be issued in regard to the speed for which curves are to be elevated.

Determine the elevation of the various degrees of curve in use by the formula $E = 0.00066\ D.\ V.$

Where E = elevation of outer rail in inches

D = degree of curve

V = velocity in miles per hour.

Enter the diagram on the left at the assumed cost of operation per train mile, follow horizontally to the elevation of the curve in inches, vertically to the velocity in miles per hour, and horizontally to the right to obtain the negative value of one degree of curve for one train per day per annum.

For instance: a 6° curve has an elevation of 6″ and the speed of the train is assumed at 40 miles per hour. Assume the train mile cost to be $1.50, then entering at $1.50 follow to line $E = 6''$, vertically to $V = 40$, horizontally to 55 cts. which is the additional cost of operating one train daily (in one direction) per anum for each degree of central angle of a 6° curve under the conditions assumed.

To find the capitalized value of this at 6% follow back horizontally from 55 cts. to the dotted 6% line and vertically downwards to $9.00 which is the amount which may be spent to eliminate one degree of this curve for each train at this speed.

Elevations over 8″ are not permissable, curves requiring trains to slow down have a larger negative value, and on very sharp curves there should be additional allowance for rail braces, tie plates, etc.

Note—The theory on which this diagram is based is that sharper curves have a larger negative value than flatter ones, and that any curve is more objectionable to fast trains than to slow trains. To use it, the traffic should be divided into one or more classes, say fast passenger trains, slow passenger trains and fast freights (though often some of these latter should go in the first class) and ordinary freights.

Take, for instance, a road where the curves are elevated for an average speed of 40 miles per hour, which gives practically 1 inch per degree (slightly over), with operating expenses at $1.40 per train mile, it will be seen that for passenger trains travelling at 50 miles per hour the ngative value of a 4° curve is about 52 cts. per degree of central angle per train, while for a 6° curve it is about 64 cts. per degree of central angle. Similarly, for freight trains at, say, 20 miles per hour, these values would be 21 and 26 cts. respectively.

DISTANCE.

The additional cost of operation per train (in one direction) per annum may be estimated as follows:

Minor changes train wages not affected....	0.03 per foot
Greater changes train wages not affected..	200.00 per mile
Greater changes train wages affected.....	250.00 per mile

The above is based on an operating cost of $1.20 per train mile. For different train mile cost adjust accordingly in direct proportion.

RISE AND FALL.

Additional cost, per train (in one direction) per annum per foot (1 ft. up and 1 ft. down):

Class B	1.00	1.50
Class C	1.80	2.75

Class A grades are those which are so light and short that they are overcome by momentum and do not affect operating expenses.

Class B are intermediate between A and C.

Class C are long stretches of maximum grade, taxing the full power of the engine in ascending and involving the use of the brakes and sand in descending.

Capitalize the amounts obtained as above at rate of 6% per annum unless otherwise instructed.

The above is based on an operating cost of $1.20 per train mile, and an average resistance of about 7½ lbs. per ton. Modify for different train mile costs and train resistance, increasing the additional cost of rise and fall as given above in direct proportion with **increase** in train mile cost and **decrease** in train resistance.

Note—The cost of rise and fall is almost entirely due to increased fuel consumption. For Class B grades, this is about

80% of the total cost of rise and fall and on Class C about 70%, the balance being for wear and tear on rolling stock due to application of brakes, etc. The cost of fuel for the larger roads in the United States averages, quite consistently, about 10% to 11% of the total operating cost. If there is reason to vary this item very much, the above values for rise and fall should be varied accordingly. The determination of the class to which a certain grade belongs depends upon a wide range of conditions. For ordinary purposes a rough classification may do, otherwise a more careful study from a profile of virtual grades and other data is necessary.

PUSHER ENGINES.

The cost of operating a pusher engine may be estimated at $15,000 to $20,000 per annum for ordinary engines. Where large engines of the Mallet type are used it will be more than this. This will permit the expenditure of from $250,000 upwards (for each engine required to handle the traffic) to avoid the pusher grade. A table of balanced grades for pusher engines is given at the end.

Use the following form for comparing the economic value of two or more lines:

	Data		Capitalized Value	
	Line A	Line B	Line A	Line B
1. Total length				
2. Total degrees of 1° curve at.....				
3. Total degrees of 2° curve at....				
4. Total degrees of 3° curve at.....				
5. Total degrees of 4° curve at....				
6. Total degrees of 5° curve at.....				
7. Total ft. rise & fall Class B at				
8. Total ft. rise & fall Class C				
9. Cost of construction: Permanent				
10. Cost of construction: Temporary				
11. Right of Way.....				
Totals				

Note—The capitalized value of Item 10 is the original cost, plus an amount which will produce, during the life of the structure, sufficient interest for its renewal at the end of its life. (For wooden structures, the life of which may be assumed to be about 10 years, the capitalized value may be assumed to be approximately double the original cost.

NOTES AND NOTE BOOKS.

All note books will be numbered before leaving the Chief Engineer's office, and every book issued, no matter for what purpose used, must be accounted for. Locating engineers will be held strictly responsible for all books issued.

Transit note books are numbered from.... 10000 to 19999
Level note books are numbered from..... 20000 to 29999
Topography note books are numbered from 30000 to 39999

All note books must be kept in the stationery chest except when in use.

Notes must be carefully kept in the manner shown (Figs. 1, 2 & 3) and checked as hereinafter described under the instructions in regard to the duties of transitman, leveller, topographer, etc.

On no account are any notes to be destroyed or erased. If lines are abandoned, draw two light diagonal lines across the page leaving the notes still legible.

Note books are to be paged as soon as issued. The first ruled page is to be reserved for an index and the index kept up to date each day.

Put a title on the inside of the cover in the following form:

X. Y. & Z. R. R.
Preliminary Levels
Harrison to Plainfield
Mile to
John Thomas, Locating Engineer Started.....
Wm. Harris, Levelman Finished.....

A copy of the transit notes must be made each night for an office copy.

When side or spur lines are run, the notes referring to all intersections or closures must be carefully cross-referenced at both places; that is, at both the old and the new notes. For instance: If a side line is started at station 743 of the main line, opposite the 0 of the side line, note that it equals Sta. 743 line.... See Note Book.....Page..... Opposite Sta. 743 of the main line, whether in the same book or another, note: —Equals Sta. 0 line..... See Note Book.....Page.....

Where an intersection or connection is made between two lines make a sketch opposite the notes of BOTH lines with references to note book, number, and page.

Reference level notes in same manner.

At end and beginning of each day's topography, note number of book and page of succeeding and preceding stations, respectively.

Each level note book must record derivation of datum plane, on which levels are based, on front page.

Equality stations must be carefully described so that there can be no doubt as to whether the line is longer or shorter.

All notes must be entered at once in note books in the field and not on paper or memorandum books and afterwards copied.

The beginning and end of each day's work is to be noted with date and hour, also notes as to weather conditions, etc., especially if these may affect the accuracy of the work.

The following abbreviations are to be used in note books:

P. C.—Point of Curve or Beginning of Curve.

P. C. C.—Point of Compound Curve.

P. T.—Point of Tangent or End of Curve.

P. I.—Point of Intersection.

T. P.—Turning Point.

B. S.—Back Sight.

F. S.—Fore Sight.

H. I.—Height of Instrument.

B. M.—Bench Mark.

H. W.—High Water.

L. W.—Low Water.

 —Instrument Point.

 —Tack in stake or hub not occupied by instrument.

$\angle$ —Central Angle.

S. T.—Semi-Tangent.

L. C.—Length of Curve.

ORGANIZATION & DUTIES.

The organization of full parties on location will be as follows. The salaries named are the maximum which will be paid. Men may be started on probation at lower rates but it is expected that each man will be efficient enough to earn the full salary within a short time from joining or after promotion:

Locating Engineer	.....per month
Asistant Engineer	.....per month
Transitman	.....per month
Topographer	.....per month
Draftsman	.....per month
Levelman	.....per month
Level Rodman	.....per month
Head Chainman	.....per month
Rear Chainman	.....per month
Stadia Rodman	.....per month
Topographer's Tape Man.....	.....per month
Back Flagman	.....per month
Stakemaker	.....per month
Cook	.....per month
Cook's Helper	.....per month
Axemen	.....per month
Teamsters and Team, with feed..	.....per month

LOCATING ENGINEER.

The engineer in charge is expected to exercise a general supervision over the whole party, to see that each part of it and each individual understands his duties and works conscientiously to carry them out. He is personally responsible for results and, therefore, should not keep any men who are not capable of doing first class work after a thorough trial and after they have received proper **instructions.** He is expected to explore a sufficiently large area to be sure that all possible routes have been investigated. The selection of the best line the country affords must be the final result of the actual elimination of **all** other possible routes after investigation of each in more or less complete detail. It is not always necessary to run a line over every route, nor is it necessary to take topography on every line run, but either or both of these things should be done, if necessary to remove the last doubt as to its practicability or feasibility.

There must be absolutely no doubt that the best route is covered by the topography on the map. There may be room for discussion as to some of the details of the location after it is made, that is, the fitting of the line to the topography or the ground, or of the grade line to the profile, but there must be

no possible chance of the proper line being outside of the topography. It is extremely important that the drainage should be thoroughly studied and understood. The locating engineer should know where every stream (or in dry countries depressions which may contain streams in wet weather), in the immediate vicinity of any of the lines, flows and joins with other streams of the main drainage. The general drainage must be carefully shown on the 5000 ft. map, correctly within reasonable limits, as also of course on the general topographical maps.

The difference between locating a line on which a railroad **can** be built, and the making of a survey which **without doubt** covers the **best route** must be kept constantly in mind.

As the engineer in charge is usually expected to cover a large area of country, other means of transportation besides walking should be availed of when possible. A saddle animal is usually desirable and will be furnished at the company's expense when it can be used. If not, such means of transportation as are available and suitable for the country should be used as far as possible and within reasonable limits.

It should not be necessary, and it is not desirable, that the locating engineer spend much of his time with the transit party. He should explore the country on either side of the line and thoroughly familiarize himself with all the details of the topography and the general physical characteristics of the country in which he is working. As the map is generally in use in the evening, he should make his projections as a rule sometime during the day. This work is important, it is the actual selection of the line, and should not usually be left until the last thing at night.

The engineer in charge is expected to see that there is an ample supply of provisions and that they are properly cooked, and that while the men are well supplied, there is no waste. None of the members of the party should be allowed in the cook tent except at meal hours. The men should be seated at the table in the order of their rank.

THE ASSISTANT ENGINEER.

Will usually have direct charge of all the field work but will necessarily confine himself almost entirely to directing the work of the transit party. The engineer in charge will indicate

where the lines are to be run and the results he desires to attain, and the Assistant Engineer will direct the work of the party so as to obtain the required information. He will exercise such supervision of the individual members of the party as may be necessary to see that their duties are properly performed, or as may be directed by the locating engineer.

On the final location the Assistant Engineer will perform such duties as may be indicated by the engineer in charge.

TRANSITMAN.

The transit man is expected to run the transit ordinarily and is responsible for the instrumental work of the alignment and notes of the same.

Read carefully the instructions in regard to notes and note books and keep notes in the form shown in Fig. 1 and 2.

On Preliminary lines, give line for the hub. When the hub is driven have the tack driven in the centre of it without giving line again. Then setting on zero and carefully sighting on the back sight turn the angle to the tack in the hub and double it.

Double all angles.

Read the needle and check the calculated course with the needle course **Before Picking Up** and be sure that you have a check that the angle has been sighted, read and recorded correctly.

When producing line ahead, all points must be **"double-centered"** or, as it is otherwise expressed, the telescope must be **"reversed both ways."**

On location, when sighting at back sight or foresight enough of the rod must be visible so that the transitman can see that it is held plumb, and to within two feet of the bottom of it. On preliminary the transitman must be satisfied that he can see enough to be sure of reasonable accuracy.

Hubs on preliminary can almost always be set at even stations and this should be done unless there is a very good reason for not doing so.

Sights on location should be limited to about 1000 ft. on tangent and 800 ft. or 15° deflection on curves.

Take observations to determine the true meridian every 25

or 30 miles at least. Get a direct intersection of the true meridian with the line, not merely checking the variation of the needle.

Make a copy of all notes each night in the office copy note book.

Check the numbering of the stations as you move ahead to the next transit point.

Have the back flagman keep a list in a note book of the stations of all hubs he holds on, as a check on the proper recording of station numbers, and also that he has held on the right points. Check up with him at noon and at night.

Where the land is divided into sections, ties must be obtained to the section corners by the transit party.

CHAINMEN.

See that chainmen check up the band tapes every few days with the accurate steel tape which is to be kept in the office tent and used for no other purpose, and that rear chainmen check the numbering of stakes. When plus stations are set for instrument points or for other purposes, measure full station when going ahead, from last even station.

TOPOGRAPHER.

The topographer will be provided with a clinometer. If this is lost he will be charged with its value. He should have a 50 ft. cloth tape and a short homemade rod.

Topography will usually be taken for 300 ft. on either side of the centre line. Contours will be located on the ground at even five ft. elevations. Level notes will be obtained from the level man and entered in the topography book each evening to cover the following day's work. In open country with regular slopes, slope angles may be taken. All topography taken is to be platted.

As it is necessary to have two or more note books in use, be sure notes are properly cross-referenced.

Have a general index book where the stationing of each line is kept continuously with reference to the book and page where the topography notes are to be found.

Usually, distances out from the centre line will be paced, the topographer, however, must study carefully the requirements of the work to the end that a proper degree of accuracy

may be attained. Too great accuracy delays the work; too little makes it of no use.

In addition to the contours, the topographer will note the general character of the country, wooded and cultivated areas, fences, buildings, rock outcrops, etc.

Where note books are not available, a very satisfactory method is to plat the line before going into the field on sheets of tough, thin paper which can be fastened to a light board by thumb tacks, sketching and platting the contours on this map in the field as they are located by the tapeman and the hand level. The stations should be carefully marked and the letter of the line shown so that the sheets may be easily identified. These sheets may then be fitted over the line on the map and the contours transferred with carbon paper.

LEVELLER.

Read carefully the instructions in regard to notes and note books and keep notes in form shown in Fig. 3.

Refer all levels to Sea Level if possible, if not, assume datum plane which will obviate the necessity of using minus elevations, and if relation to Sea Level is found later, show this in note at beginning of all books. When starting from existing lines, connect carefully with datum plane of that line and describe fully source of information and starting point.

Establish Bench Marks every mile on preliminary with at least one or more turning points between, which can easily be picked up; on location, every half mile, where they will not be disturbed by the grading and near the elevation of the profile grade line, which can be ascertained from the projected profile. All Bench Marks must be turning points, must be very carefully described and tied in so that they may be found, and have the elevations plainly marked on them. Describe enough intermediate turning points so that the levels can be easily picked up at any point on the line.

No sights are to be taken over 600 ft. in length on preliminary or over 300 ft. on location and back sights and fore sights should be equalized. Read ground elevations to nearest tenth, T. P.'s to nearest hundredth. Ground elevations should be worked out as the work progresses, not left until night. A

hand level may be used to get steep, narrow draws on preliminary.

A hand level will be provided for the leveller who will be charged with its value if lost. It should be used whenever necessary to avoid loss of time in setting up.

Get elevations of high water, at all water courses large or small and search carefully for drift marks, etc. Where the line is in a valley with grade nearly parallel to the flood mark, get elevation of water surface (normal and flood level), depth of water, etc., at least every quarter mile, and show on profile with a dash line.

The rodman is to keep a full set of notes of turning points and make independent check. When reading the rod on T. P.'s first read the rod with the instrument and note, but don't call out the reading, then set the target and let the rodmen read it and call the reading. Work out elevations independently but don't call readings until both are through figuring. On preliminary after reading the rod, call the reading to the rodman and let him set the rod at this reading, then sight and see if the target is O. K. This is a little quicker but also gives check on the reading.

Check notes at noon and at night by addition of back sights and fore sights and have rodman check all deductions of elevations of ground. Cross reference all checks with previous levels in **both** note books.

Plat the profile in the same direction as the line is platted on the map.

On location, at all places where bridges or culverts are required, take levels every 10 ft. on the centre line, measuring with tape, and 20 ft. either side (more if required). At culverts take cross sections up and down stream to cover length.

Plat these sections on cross section paper. See Site Plans or Ravine Sections.

MAPS.

The following maps, profiles, etc., are required:

General map and profile 5000 ft. to the inch (or 2000 ft. to the inch in some cases).

Detail map with topography, usually 400 ft. to the inch.

Profiles on Plate A paper, preliminary, projected, location.

Tracing of Projected Profile. Grade line inked in. 10 mile sections.

Tracing of Location Profile. Grade line in pencil.

Estimates of quantities from Projected Location.

Estimates of quantities from Final Location.

Site Plans or Ravine Sections 10 ft. to the inch.

Right of Way map.

Estimates.

Tabulated statement of physical characteristics and costs.

All maps must be kept up to date with the progress of the survey, and conform to these instructions.

All maps and profiles are to face West or North.

Leave about 1 ft. blank at the end of all rolls for title and wrapper.

Put titles on **both ends,** on the outside of all rolls as soon as maps and profiles are started.

Titles to be written parallel to the end of the **paper.**

Give the name of the railroad:

Name of the line, division or branch.

Dates between which survey was made.

Letters of the preliminary lines.

Stations of main line (make stations read in direction map will open. For instance: Sta. 675 to 1120 at the end nearest 675 and Sta. 1120 to 675 at the end nearest 1120).

On the inside give names of all concerned in making map, whether getting information in the field or office. Give full names and titles.

Use water color **paint** for colors on tracings so that lines will blue print.

5000 FT. MAP.

Plat on manila paper. Cover whole area within which surveys are likely to lie. Compile at beginning of survey from best information available and correct as survey progresses. As the projected location is made, plat profile at bottom on scales of 5000 ft. horizontal to 500 ft. vertical. These maps are to be 15" wide, not over 36" long (length to suit survey), margin 2" on left, ½" on other three sides (margin inside of dimension given). Make tracing and send to headquarters as soon as possible after survey is started. Send small tracings each week with

report showing all lines run and any corrections or additions developed by the survey, particularly the general drainage (see Fig. 4).

DETAIL MAP.

Plat on manila paper 400 ft. to the inch, unless otherwise instructed, continuous rolls 24" wide covering about 20 miles of line per roll. If any short sections require larger scale to develop details, plat on separate paper but continue 400 ft. map. Use care in starting map so that it will stay on the paper as long as possible. Keep edge of topography 4" from edge of paper. Don't paste pieces on the edge of the map to keep the line from running off (see Fig. 5).

Plat map by laying off calculated course from a meridian.

Platting of preliminary lines must be checked. Usually they should be platted by the draftsman and checked by the Assistant Engineer. **This is very important.**

Ink in preliminary at once in red ink. Make small circles at angle points before drawing lines.

Show stations of angle points, and even 5 and 10 stations. Make short perpendicular dash, 1/16", at each station. Show magnetic variations at intervals of 25 to 30 miles, from observations.

In platting topography, scale distances at each station and sketch between by eye, or use equally efficient method.

Ink in topography at once, even 25 ft. in heavier lines, contours in brown, streams or thread of valley in blue with arrow showing direction of flow, dotted contours below water in lakes and rivers. Buildings, fences, property lines, etc., in black.

Show position and name of any settlement, houses, buildings or homesteads, mineral claims, town sites, etc.

Leave projected location in **pencil.**

When final location is completed.

Ink in centre line in black, dot radial lines of curves.

Show degree of curve,

central angle,

stations of P. C. and P. T.

true bearing of tangents.

Stations and true bearing of property lines.

Names of property owners.

Angle of centre line with property lines.

Political sub-divisions, names of rivers, streams, etc.
Stations of both sides of roads.

PROFILES.

Profiles will usually be platted on Plate A paper, using half width (11 ins.). Where ruling grade is 2.5% or over use Plate B or whole width of roll Plate A. (See Fig. 6.)

Profiles of preliminary lines should be platted by the leveller, the rodman calling off the elevations. This should be done as soon as possible after getting in from the field. Leave in pencil.

Field copies of projected profiles may be left in pencil (4 H). They should show practically the same information as is required for profiles of final location, as noted below and shown in example at the end. They need not show stations of P. C. and P. T. or width of Right of Way.

Make tracing of profiles of projected location on tracing profile paper in sections of 10 miles. Ink in everything, grade line in red, and send to headquarters as soon as completed or with weekly report, with tabulation of quantities, etc.

On final location the ground line on field copy will be platted by the leveller.

Leave grade line in pencil on both the field copy and the tracing.

Show alignment, degree of curve, central angle
Stations of P. C. and P. T.
Right of Way and property owners names.
Rate of grade and elevation of change points.
Quantities in each cut and fill classified.
Results of soundings, approximate top of rock, etc.
Distribution of quantities.
Structures, kind, size, quantity of material.
Tabulation of earthwork each mile.
Mile posts.
Cultivation, timber, etc.

All breaks in stations are to be indicated as follows:

When the difference is less than one station, the profile will be made continuous and the discrepancy indicated by two heavy lines and the words long or short station with its length. When the break is for more than one station and there is a gap

in the stationing, leave equivalent opening on the profile with note of exact length. When there is a duplication of stationing, the profile may be lapped over or a break made, as may be most convenient to show the line clearly, but in either case so as to leave the stations at the bottom of the profile with the even tens on the heavy lines.

Make tracing in 20 to 25 mile sections and send to headquarters, all inked in except grade line, rate of grade and elevations of grade line which are to be left in pencil.

SITE PLANS.

Site plans on a scale of 20 ft. to the inch on sheets 24 x 36", 1" margin top, bottom, right, 2½" left (margin inside these dimensions), are to be made of the sites of all important bridges and other structures. They should show the elevation of the ground, either by contours or by actual elevations (if the latter, make the decimal point at the spot) for a sufficient distance on either side of the centre line to cover all slopes, bridges, wings, etc.

In the case of wooden pile bridges, plat the profile on cross section paper sheet 18 x 22" 10 ft. to the inch, showing subgrade, alignment, and location of each bent, length of piles proposed, results of soundings. See Ravine Sections, Fig. 7.

RIGHT-OF-WAY.

Right of Way maps are to be made on separate sheets 18" x 30" in size, 1" margin top, bottom and right, 2½" margin at left. Scale 200 ft. to the inch, each sheet to contain one mile (mile post to mile post). They are to show (see Fig. 8).

Centre line in red (paint).

True bearing of tangents.

Curves, Station of P. C. and P. T.

Radius.

Central angle and degree.

Width of Right of Way—100 ft. except where more is required for construction.

Property lines:

Angle with centre line.

On curves, angle with tangent to curve at point of intersection.

Station of intersection.

True bearing.

Property owners names.

Area in acres of each taking (sq. ft. in towns, etc., where holdings are small and land valuable).

Names of political sub-divisions, town, country, state, etc., streams, rivers, etc. ...

Distances to nearest section corners in land laid out by U. S. Public Lands survey.

Relation of Right of Way taken to rest of property of the various owners, all buildings within 300 ft. of centre line.

ESTIMATES.

Estimates of quantities of excavation, etc., are to be made of projected as well as final locations, the materials are to be classified as closely as possible from the information available, and their distribution shown on the profile (see Fig. 6). Length of haul and amount of overhaul are to be calculated approximately and amount of borrow and waste, if any shown.

Scale earthwork quantities by using quantity scale and make proper allowance for steep transverse slopes, platting cross sections if necessary.

Materials required in all structures are to be calculated from standard plans or in accordance with other instructions which may be issued. Make proper allowance for cut and side ditches, stream diversions, channel changes. Show separately quantities in embankments, between bridges and ends of cuts.

Estimates for each mile are to be made out on regular estimate sheets as for construction, showing each cut and fill, each structure, etc., and total at the bottom. These are to be made in pencil and kept in camp (see Fig. 9).

Summary for each mile is to be shown on profile.

For each 20 to 25 miles make out summary on regular estimate sheets, showing the totals of each mile (one mile to each line) and the totals for the section. Make ink copy and send to headquarters with profile, keeping pencil copy with the field records.

On all estimate sheets show:

Name of railroad.

Name of line, division or branch.

Mile or Miles, origin of mileage.
Whether from projected or final location.
Name of Locating engineer and draftsman.

The summaries should separate, so far as possible, the various natural divisions into which the country may be divided.

REPORT.

With each section of 10 to 25 miles of both projected and final location, for which profile and estimate of quantities is sent in, send estimate of cost, etc., in the following form:

X. Y. & Z. R. R.

Chandler—Okmulgee Line.

Estimate of Cost of Construction of.....miles. Mile..... to mile.....from

Preliminary / Final } Location

.....
Locating Engineer.

Clearing & Grubbing	Acre
Excavation:	
earth	Cu. yd.
loose rock	Cu. yd.
solid rock	Cu. yd.
Overhaul	Cu. yd.
Excavation under water	Cu. yd.
Tunnels, excavation	Lin. ft.
Masonry:	
1st Class	Cu. ft.
2nd Class	Cu. ft.
3rd Class	Cu. ft.
Paving and Riprap	Cu. ft.
Timber in foundations	M. ft. B. M.
Bridges:	
steel	Lb.
piles	Lin. ft.
timber	M. ft. B. M.
Vitrified Pipe, 24"	Lin. ft.
Iron Pipe, 24"	Lin. ft.
Iron Pipe, 36"	Lin. ft.

Road Crossings & Signs	Each
Crossing Gates	Set
Telegraph Line	Mile
Fencing, both sides	Mile
Track, laid and surfaced	Mile
Ballast	Mile

Total

Give decimal of mile to nearest hundredth.
Total length.
Average cost per mile.
Total degrees curve.
Total length tangent.
Per cent on tangent.
Maximum curve.
Maximum grade.
Ruling grade.

Total rise and fall { N / W / S / E } bound

Length of Bridging—permanent
temporary

All locations are to be made originally on the basis that there is ample money available to build the line best suited to the governing conditions, and with a reasonable consideration for future business. At all points where temporary structures may be built, or the immediate cost of construction lessened, notes are to be made and attention called to the possibilities, in the report accompanying the profile and map of the projected location. Much more satisfactory results are usually obtained by working down towards a cheaper line from one of good grades and alignment than by the reverse process.

Locate the **best line** and then if necessary cheapen construction of **that line** by such expedients as may be necessary.

FINAL LOCATION.

The location is to be projected on the topographical map, by the engineer in charge, who is expected, by the time he is ready to do this, to be thoroughly familiar with the ground and the general situation.

Profiles of the projected location are to be made and quantities calculated and distributed as for the final line.

Although the line is to be projected on the map and the results desired worked out there, the actual location is to be **made on the ground,** and the skill of the locater will be shown by his ability to fit his line to the ground and obtain or better the results which his projected line has shown are possible. For this purpose the engineer in charge will necessarily be with the party a considerable part of the time.

On location care must be taken that the line falls on every stake and that all stakes are properly and clearly marked. Blaze stakes on back side so that cut or fill may be marked later on. Use large hubs. Drive hubs near fence lines, where they can be used for locating property lines, and so that the line will not be lost. This is especially important in cultivated country where transit points come in the middle of fields where they may be disturbed. Put in stakes every 50 ft. on curves over 8° and use only oak, chestnut or hard pine on location. Stakes must all be well driven and fit to stand at least two or three years. When the proposed new line starts from a point on an existing line, locate standard frog at nearest joint, turn off proper frog angle and establish starting point to conform.

The level rod should be held close to and just behind each stake and readings to nearest hundredths taken on all hubs.

Every endeavor should be made to make the line right as the work progresses, and for this purpose the leveller should have enough profile paper with him, so that he can plat the profile as may be required, and it can be seen at once whether the proper results are being obtained or not.

During the progress of the location the following work must be done, the Assistant Engineer and Topographer, with such other men as may be available, being assigned to it:

a. Soundings must be taken in all cuts when necessary to determine the character of the material, and at the sites of all structures to determine the length of piles, depth of foundation, etc., at swamps and at crossings of bodies of water. Usually the necessary information can be obtained by crowbars, sounding rods, pointed gas pipes, augurs with long handles and an adjustable arm, etc. Where anything

more elaborate seems to be required, the head office is to be notified so that the necessary arrangements can be made.

b. Property lines must be accurately tied in. See Right of Way maps.

c. Drainage areas must be determined and shown on maps.

d. Roads and streams traversed if necessary when changes are to be made.

e. Surveys of bridge sites and levels. Leveller to get detail profile of bridge crossings.

Stakes on location are to be marked L with the station number. Beginning of curve to be marked P. C. with degree of curve and direction left or right (P. C. 3° R. 714 + 53.2). End of curve to be marked P. T. Curves may be offset for spirals and run in as simple curves, two hubs being set at P. C. and P. T. Velocity or momentum grades are not to be used. Where there is apparently an opportunity to use them to advantage, they may be shown in pencil and attention called to them in the report to the Chief Engineer.

After the final profile has been platted, the grade line put on **in pencil,** the quantities figured and the distribution made and put on also **in pencil,** the engineer in charge must take this profile and **walk** over the line, carefully examining it on the ground in the light of the complete knowledge he should then have.

Examine every water course carefully, fix the size of the opening required, see where the locations of abutments, piers, toe of slope, etc., are going to be **on the ground.** This examination should preferably be made after the soundings have been taken but it should be kept fairly close up to date. In case the soundings are taken afterwards, their effect on the quantities, etc., must be carefully considered and proper adjustment made if necessary. The profile of the final location is to be completed as shown in the sample profile at the end but the grade line **must not be inked in,** leave it in pencil. All the other information on both the field copy and the tracing is to be completed and inked in. On the detail map, ink in the final location in black after the line is finally completed on the ground and the profile worked up.

On the completion of the surveys of any particular line, a complete list is to be made of all note books, records, estimates, maps, profiles, etc. These are then to be carefully packed and forwarded to the office of the Chief Engineer, or such other person as may be designated. When these records, etc., are not forwarded directly to headquarters, a copy of the list is to be forwarded to the Chief Engineer's office with a note showing to whom they were delivered. One copy of the list is to be sent with the records and one should be retained by the engineer in charge.

SURVEYING INSTRUMENTS, ETC.

1 Standard transit about 6" circle.
1 Small transit with stadia wires, vertical arc, etc.
1 Level.
1 Bottle watch oil.
2 Clinometers.
2 Hand levels.
2 Level rods.
1 Topographer's rod.
3 Steel band tapes, 100 ft. each.
1 Steel tape graduated to hundredths, tested.
1 Tape mending outfit.
3 Brass plumb bobs, 8 oz.
3 Doz. red crayons.
4 Sighting rods.
2 Yds. red flannel.
2 Yds. white flannel.
3 50 ft. metallic (cloth) tapes.
8 Lb. sledges, extra handles.
3 Axes, extra handles.
3 Brush hooks.
1 Water keg, 2 gals.
3 Canteens, 2 qts. covered.
2 Hand axes, sheath and belt.
1 Sounding rod.
12 Transit books.
18 Level books.
12 Topography books.
2 Drafting boards.
1 Stationery chest.

Stadia tables.
Table of Lograthims.
Curve tables.

1 Roll 25 yds. Manilla paper 24″ or 48″ wide.
1 Roll 50 yds. Tracing cloth 24″ wide.
1 Roll 25 yds. Tracing paper 24″ wide.
1 Roll 50 yds. Profile paper (Plate A).
1 Roll 25 yds. Profile tracing paper.
50 Sheets cross section paper 10 ft. to 1″.
50 Sheets cross section tracing paper 10 ft. to 1″.
2 Tin map cases 6 x 30.
2 Tin map cases 3 x 30.
2 Cardboard protractors 13″.
2 Transparent paper protractors 13″.
1 36″ steel straight edge.
1 45° triangle 12″.
1 60° x 30° triangle 12″.
1 Triangular scale 12″.
3 Flat scales 10, 20 and 40.
4 doz. thumb tacks.
1 doz. Ruby erasers.
1 Erasing shield.
¼ Doz. ink erasers.
3 Bottles black India ink.
2 Bottles red drawing ink.
1 Bottle blue drawing ink.
½ Pan vermillion.
½ Pan burnt sienna.
½ Pan Prussian blue.
3 Camel's hair brushes.
2 Doz. H B pencils.
2 Doz. 2 H pencils.
2 Doz. 3 H pencils.
½ Doz. 6 H pencils.
12 Half red and blue pencils.
1 Box writing pens.
1 Doz. Gillots 303.
1 Doz. Gillots 404.
½ Doz. pen holders.
½ Pt. writing and copying ink.

1 Small inkstand.
1 Bottle photo paste.

STATIONERY.

200 Letter heads.
100 Envelopes, letter size.
50 Envelopes, large size.
2 Bushnell's letter copy books.
2 Doz. figuring pads, 8 x 12½.
2 Doz. figuring pads, 5 x 8.
2 Doz. figuring pads, 3 x 4.
Paper fasteners.
Rubber bands.
Blotters.
Wrapping paper.
Shipping tags.
Twine.

BLANK FORMS.

Time checks.
Requisition blanks.
Payrolls.
Estimate sheets.
Expense account blanks.
Construction contracts.

MEDICAL EQUIPMENT.

500 5 gr. quinine pills.
200 Compound cathartic pills U. S. pharmacopia.
200 Sun cholera mixture tablets.
100 3 gr. acetanilid or phenacetine tablets.
100 5 gr. bichloride of mercury tablets.
2 Surgical needles with silk in sealed glass tubes.
½ Doz. rolls bandages about 4" wide.
Absorbent cotton.
1 Hypordermic syringe.
For use with hypordermic:
Morphine.
Strychnine.
Permangante potash.
Instructions how to use above.
Book of First Aid.

CAMP EQUIPMENT.

1 Office tent with fly.
3 Tents.
1 Cook tent.
3 Drafting and office tables.
½ Doz. camp chairs.
Stationery and Map chest.

DINING TABLE.

3 Doz. agate ware dinner plates.
3 Doz. agate ware cups.
2 Doz. agate ware saucers.
2½ Doz. steel knives.
2½ Doz. steel forks.
2½ Doz. German silver teaspoons.
1½ Doz. German silver dessert spoons.
1 Doz. German silver table spoons.
½ Doz. tin salt boxes.
½ Doz. tin pepper boxes.
½ Doz. tin round agate ware pans, 2 qt.
½ Doz. round agate ware pans, 1 qt.
1 Doz. tin round agate ware pans, 1 pt.
1 Carving knife and fork.
7 Yds. oilcloth, 48" wide.
3 Standard trestles (see sketch).
5 Boards, 12 x 1½" x 18' (dressed).

COOKING UTENSILS.

1 No. 8, 6-hole, wrought iron range.
1 Tea kettle.
1 Large cast iron pot.
1 Small cast iron pot.
2 Large frying pans.
1 Small frying pan.
2 Griddles.
4 Tin pans with covers, 1 gal. each.
2 Stew pans.
1 3-gallon coffee-pot.
1 Gal. tea-pot.
4 Dripping-pans.
6 Baking tins for bread.

12 Tin pie plates.
2 Butcher knives.
1 Steel.
2 Large meat forks.
1 Chopping knife.
1 Meat saw.
2 Large iron spoons.
1 Soup ladle.
1 Cake turner.
1 Flour sieve.
1 Colander.
1 5-gal. tin dishpan.
1 5-gal. tin bread pan with cover.
1 Chopping bowl.
1 Bread board.
1 Rolling-pin.
1 Biscuit cutter.
1 Nutmeg grater.
1 Coffee mill.
1 Spring balance.
6 Galvanized iron buckets.
6 Tin dippers (one for each tent and two in cook tent).
2 Can openers.
1 Corkscrew.
1 Broom.
1 Scrubbing brush.
1 Alarm clock.
1 Table (same as drafting tables).

MISCELLANEOUS.

½ Doz. Dietz lanterns.
3 Large tin lamps (central-draft, round wicks).
2 Large galvanized iron washtubs.
1 Washboard.
4 Sibley stoves (4 lengths of pipe with dampers, 12 lengths of plain pipe) (See Fig. 1).
2 Water kegs, 2 gal. each.
6 Washbasins.

TOOLS.

1 Grindstone and fittings.
1 Monkey wrench.
1 Pick.
2 Shovels.
1 Short crowbar.
1 Hand saw.
1 Cross-cut saw.
2 Hand axes.
4 Chopping axes.
½ Doz. axe handles.
1 Bundle sail twine.
½ Doz. sail needles.
1 Sail palm.
10 Lbs. assorted sizes wire nails.
100 Feet manila rope, ¾".

LUNCH BOX.

2 Doz. agate ware dinner plates.
2 Doz. agate ware saucers.
1½ Doz. steel knives.
1½ Doz. steel forks.
1½ Doz. German silver teaspoons.
1½ Doz. German silver dessert spoons.
1 2-gal. coffee-pot.

SUPPLIES.

The following is a list of groceries, etc., actually bought on starting a camp. With some additional meat, this will last a party of 14 to 20 men about two weeks or longer. It can, of course, be modified to suit the country:

6 Hams.
6 Pieces of bacon.
50 Lbs. fresh beef.
1 Case eggs.
25 Lbs. butter.
25 Lbs. lard.
100 Lbs. flour, hard wheat.
100 Lbs. flour, soft wheat.
100 Lbs. sugar.

5 Lbs. baking powder.
2 Lbs. baking soda.
2 Lbs. tea.
50 Lbs. coffee.
50 Lbs. navy beans.
25 Lbs. lima beans.
12 Lbs. buckwheat flour.
5 Lbs. macaroni.
35 Lbs. corn meal.
1 Cheese (about 15 lbs.).
12 Packages oatmeal.
10 Lbs. rice.
100 Cakes of soap.
1 Doz. sapolio.
2 Lbs. lye.
10 Lbs. washing soda.
1 Gal. molasses.
1 Case condensed milk.
1 Doz. tomato catsup.
1 Doz. Worcestershire sauce.
1 Gal. pickles.
¼ Doz. lemon extract.
¼ Doz. vanilla extract.
5 Lbs. tapioca.
5 Lbs. sago.
2 Lbs. cornstarch.
1 Box dried prunes.
5 Lbs. raisins.
5 Lbs. currants.
4 Doz. assorted canned fruits.
1 Case tomatoes.
1 Case corn.
1 Bushel potatoes.
10 Lbs. onions.
1 Kit salt mackerel.
20 Lbs. salt.
¼ Lb. mustard.
1 Lb. pepper.
1 Oz. ginger, ground.
1 Oz. allspice, ground.

1 Oz. cinnamon, ground.
1 Oz. cloves, ground.
¼ Lb. nutmegs, whole.
1 Qt. vinegar.
½ Doz. yeast cakes.
1 Doz. boxes matches.
10 Gals. kerosene.

To the above may be added:

Dried beef.
Codfish.
Corned beef.
Canned tongue.
Smoked dried tongue.
Dried peaches.
Dried apricots.
Evaporated apples.
Beef extract.
Chocolate.
Gelatine.
Graham flour.
Barley.
Canned peas.
Canned string beans.
Canned asparagus.
Split peas.
Soda crackers.
Sea biscuit.
Cream of wheat.
Hominy.
Canned Salmon.
etc., etc.

TRAIN RESISTANCE

Train Resistance: American Railway Eng. Assoc. Formula.

$R = 2.22\ T + 121.6\ C.$

R = Total resistance in lbs. of train behind tender.

T = Total weight of train in tons.

C = Number of cars in train.

The above applies to modern equipment in good condition.

Grade Resistance:

Rate of grade in feet per mile x 20, equals grade resistance in lbs. per ton.

Tractive Power of Locomotives:

Roughly 1/5 of weight on drivers.

Draw bar pull cannot be assumed to be greater than

30% of weight on drivers at starting.

25% of weight on drivers at 5 m. p. hr.

20% of weight on drivers at 10 m. p. hr.

Tractive force developed at cylinders.

$$T = \frac{0.85\ P\ d^2\ S}{D}$$

T = Tractive force in lbs.

P = Boiler steam pressure in pounds.

d = Diameter of cylinder in inches.

S = Stroke in inches.

D = Diameter of drivers in inches.

Note—The draw bar pull is the Tractive Force less the resistance of the locomotive.

ENGINE & TENDER RESISTANCE.

The resistance of the engine and tender is usually calculated in two parts:

a. The internal resistance of the locomotive, friction of driving wheels, and moving parts of the engine, plus the Head Air Resistance, which is according to the formula of the American Locomotive Company:

$22.2 \times \text{tons on drivers} - .002V^2A$

in which V = Velocity in miles per hour

A = Area of Cross-section in sq. ft. (taken in the following table as 10 x 12 ft.)

b. The resistance of front or rear trucks and tender, is taken at the same rate as that of the train following.

The resistance due to "a" is given in the following table * in lbs.:

Resistance in Pounds on Straight Level Track

$22.2 \times t - .002V^2A.$

Tons on Drivers	Miles per Hour						
	10	20	30	40	50	60	70
20	470	540	660	830	1045	1310	1620
40	910	985	1105	1270	1490	1750	2065
60	1355	1430	1550	1715	1930	2195	2510
80	1800	1870	1990	2160	2375	2640	2950
100	2245	2315	2435	2605	2820	3085	3395
120	2690	2760	2880	3050	3265	3530	3840
140	3130	3205	3325	3490	3710	3970	4285
160	3575	3650	3770	3935	4150	4415	4730
180	4020	4090	4210	4380	4595	4860	5170
200	4465	4535	4655	4825	5040	5305	5615

Approximate average dimensions, weights, etc., of Standard Gauge Cars.

	Length over all, ft.	Weight in tons, empty.
Passenger:		
Heaviest type Pullman, diners, etc.	75 to 80	50 to 70
Mail, baggage, express and heavy passenger coaches	60 to 65	40 to 55
Ordinary coaches	45 to 50	25 to 35
Freight:		
Box Cars, 100,000 lbs.	42	20 to 25
Box Cars, 80,000 lbs.	39	18 to 20
Box Cars, 60,000 lbs.		15 to 18
Box Cars, 40,000 lbs.		13 to 15
Steel, hopper, coal & ore cars:		
100,000 lbs.	35 to 38	19 to 22
80,000 lbs.		17 to 19

Gondolas may be assumed to weigh 5 tons less than box cars of 100,000 carrying capacity, and flat cars 6 tons less. Proportionately less for lesser capacity.

Table of Typical Standard Gauge Locomotive Weights, Dimensions, Capacities, etc.

		Engine & Tender Total wgt., tons.	Length overall ft.	Weight on drivers, tons.	Tractive X power, lbs.
Atlantic	4-4-2	120	63′-5″	41.5	20,700
type		134	62′-10″	45.8	22,800
Passenger		155	70′-7″	55.0	23,800
		163	68′-3″	54.0	24,700
Consolidation	2-8-0	123	59′-2″	63.0	27,200
		148	61′-2″	73.5	37,300
		166	66′-1″	83.0	44,100
		180	69′-1″	99.0	45,700
Ten Wheelers	4-6-0	83	57′-9″	43.0	19,000
		109	58′-10″	49.5	19,500
		134	65′-9″	63.8	27,200
		160	64′-1″	71.0	31,700
Moguls	2-6-0	57	49′-4″	30.2	11,700
		97	59′-1″	46.5	22,500
		136	63′-8″	63.7	27,600
		158	64′-4″	76.0	34,700
Articulated	0-6-6-0	239	80′-0″	167.0	70,000
or	2-8-8-2	298	93′-6½″	197.0	94,600
Mallet	0-8-8-0	306	90′-0″	222.0	100,000
	2-10-10-2	425	121′-7″	275.0	111,600

X Note—This is total tractive power developed—to get draw bar pull deduct power necessary to move the engine.

BALANCED GRADES FOR HELPER ENGINES.

The following table worked out by Mr. R. M. Beigen and published in the Proceedings of the American Railway Engineering Association for 1911 (Vol. 12—1 P. 330) is based on the assumption that the helper engine, owing to the fact that it's work is not sustained for long periods of time can do 10% more work than the road engine. The American Railway Engineering Association formula for train resistance is used and the results obtained are, therefore, more nearly in accord with modern practice than Wellington's. The values are based on a coal consumption (13,000 B.T.U.) of 4,000 lbs. per hour for the road engine and 5,350 lbs. per hour for the helper engine.

The table is worked out from the following formula:

Let R = drawbar pull of road engine behind tender at given speed on level tangent,

R^1 = drawbar pull of helper engine behind tender at given speed on level tangent,

W = weight of road engine and tender, in tons,

W^1 = Weight of helper engine and tender in tons,

T = tons of weight of train,

C = number of cars in train,

G = single engine grade per cent,

X = rate per cent of helper grade.

Then a single engine will haul on X grade:

$$R - (20 \times W) = (20X + 22)\ T + 122\ C$$

Both engines will haul on X grade:

$$[R - (20\ X\ W)] + [R^1 - (20\ X\ W^1)] = (20\ X + 2.2)\ T + 122\ C$$

$$R - 20\ X\ W + R^1 - 20\ X\ W^1 = 20\ X\ T + 2.2\ T + 122\ C$$

$$R + R^1 - 2.2\ T - 122\ C = 20\ X\ T + 20\ X\ W + 20\ X\ W^1$$

$$= X\ (20\ T + 20\ W + 20\ W^1)$$

$$X = \frac{R + R^1 - 2.2\ T - 122\ C}{20\ (T + W + W^1)}$$

The table assumes that the helper can do about 10 per cent more work than the road engine. This should be a fact, as the helper engine's work is not sustained for long periods of time. These figures should be safe for grades not more than 10 miles in length.

Note—Values given are based on coal consumption of 4,000 lbs. per hour for road engine and 5,350 lbs. per hour for helper (E-24 engines—13,000 B.T.U. coal).

Road Engine Grades.	HELPER ENGINE GRADES		
	1 Helper.	2 Helpers.	3 Helpers.
Level	0.204	0.400	0.587
0.05	0.302	0.536	0.766
0.10	0.401	0.673	0.946
0.15	0.497	0.813	1.114
0.20	0.594	0.954	1.283
0.25	0.688	1.083	1.441
0.30	0.782	1.212	1.599
0.35	0.874	1.336	1.749
0.40	0.966	1.461	1.899
0.45	1.055	1.580	2.039
0.50	1.145	1.699	2.179
0.55	1.233	1.813	2.311
0.60	1.31	1.928	2.444
0.65	1.407	2.037	2.569
0.70	1.494	2.147	2.695
0.75	1.578	2.253	2.814
0.80	1.662	2.359	2.933
0.85	1.744	2.460	3.045
0.90	1.826	2.561	3.158
0.95	1.907	2.659	3.271
1.00	1.988	2.757	3.384